

Scientific insight into the debate over widespread public use of masks during COVID-19 pandemic

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On 12th March, WHO announced COVID-19 outbreak as a global pandemic ¹. To prevent further spread of COVID-19, several interventions have been suggested and adopted. While there is a unanimous agreement on measures such as social-distancing and hand hygiene, the widespread public use of masks has been a topic of debate ²⁻⁵.

What is a mask?

Mask is personal protective equipment (PPE) which functions as a barrier to droplets (respiratory droplet including larger droplet and coarse aerosols of diameter $> 5\mu\text{m}$ ⁶) and aerosols (fine-particle aerosols with aerodynamic diameter $\leq 5\mu\text{m}$ ⁶) from exhaling and inhaling to and from the environment. A mask typically consists of the following elements: Filtering material, sealing and fittings, and valve (reduces breathing resistance while exhaling, thus making breathing easy ⁷) (Figure 1). Apart from filtering material, the effectiveness of the mask depends on the seal between the face and mask ⁸.

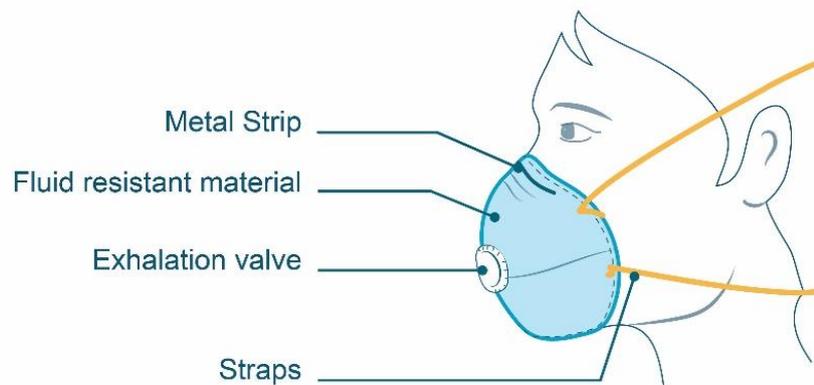


Figure 1. Parts of a mask

Types of mask

There are mainly 3 categories of mask: respirator, surgical mask and non-surgical (cloth/homemade) mask (Figure 2).



Figure 2. Types of mask

Respirator

A respirator reduces particles that are both inhaled and exhaled by the wearer⁹, and they are designed to protect wearer from droplets and aerosols transmitted directly from patient⁸. Examples of respirators include N95 and FFP2, the European equivalent of N95. N95 and FFP2 are performance standards^{7,10} and those masks who pass these standards are certified to use N95 or FFP2. N95 has been talked all around the media during this pandemic. The N in 95, stands for non-oil, whereas 95 indicates its filtering efficiency⁷. Therefore, an N95 respirator can prevent over 95% of non-oil particles (over 0.3 μm) from inhaling or exhaling⁹. Similarly, FFP2 (filtering face piece) has an efficiency of over 94%¹⁰. Respirators have a tight face seal or a low face seal leakage,¹¹ and surgical respirators are fluid resistant^{9,12}. Respirators are available with valves, however, respirator without valves are recommended during this pandemic due to the risk of virus escaping from the mask of wearer⁵.

In case of emergency situations like COVID-19 when there is a global shortage of respirators for surgical use, the expired respirators can be utilised after testing its efficiency. Lin et al. 2020¹³, found that the efficiency of an N95 mask did not reduce even after expiry and could be utilised. This may not be true for the fitting and seals and all the respirators need to be tested before use⁸. Moreover, respirators can be re-used for a limited number of times after sterilization. de Man et al.¹⁴ found that sterilization of FFP2 up to 5 times at 121°C does not affect the efficiency of a mask. Although, heating at higher temperatures can impact the elasticity of fittings.

Surgical mask

A surgical or medical mask (is made up of multiple layers of non-woven fabric or paper and has a thin metal strip or wire for adjustment over the nose⁵. The function of a surgical mask is to reduce particles expelled by the wearer into the environment⁹. These masks are also fluid-resistant and mostly used as a physical barrier for droplets. Surgical masks usually have three layers of fabric¹². The required bacterial filtration efficiency of a surgical mask, as recommended in EN 14683:2014 on medical face masks, is over 95%. It should be noted that the efficiency is measured based on the particulates of *Staphylococcus aureus*¹⁵ of size 0.5-1.5 μm ¹⁶. Its filtering efficiency has also been reported to be in a wide range of 10%-90%¹⁷. While some surgical masks have tested to provide about 10 times less protection as compared to N95 respirator (tested in aerodynamic size range: 0.04–1.3 mm), that might be caused due to face-seal leakage¹⁸. However, there is limited evidence that proves the superiority of N95 masks over surgical mask in case of transmissible respiratory infections^{11,19,20}.

Non-surgical (cloth/homemade) mask

Non-surgical, Cloth, or homemade masks are cheap and easy to make DIY masks that have been recommended for community or public use in several countries due to shortage of surgical masks. It is recommended to be used only by a non-medical worker who does not come in contact with several people. A significant number of instructional videos on how to make masks from homemade textile is available on YouTube, such as by CNN ²¹ and Dr. Ryan ²². These masks are not fluid-resistant and prevent droplets from expelling out from the wearer ¹². While the performance and effectiveness of homemade mask have been met with criticism, there are studies on home-made masks that can shed light on their efficiency.

Are homemade masks effective? And which materials are good for making a homemade mask?

Davies et al. ²³ tested efficiencies of household materials (fresh and unworn) against *Bacillus atrophaeus* (0.95-1.25µm) and Bacteriophage MS2 (0.023 µm), and concluded that these materials provide little protection to people. The filtration efficiency of these materials (2 layers) against Bacteriophage MS2 were tested (for reference, size of Coronavirus is reported to be 0.06-0.14 µm²⁴). The surgical mask had the highest measured efficiency of 90% followed by Vacuum cleaner bag (86%), Tea towel (72%), Cotton mix(70%), Antimicrobial pillow case (69%), Linen (62%), Pillowcase (57%), Silk (54%), 100% cotton T-shirt (51%) and Scarf (49%), as illustrated in Figure 3. While vacuum cleaner bag and tea towel are efficient filters, the study showed that they offer greater resistance to breathing which can lead to higher face seal leakage. Therefore, the pillowcase and 100% cotton t-shirt were recommended as the most suitable material. The stretchiness of the t-shirt could provide a better fit.

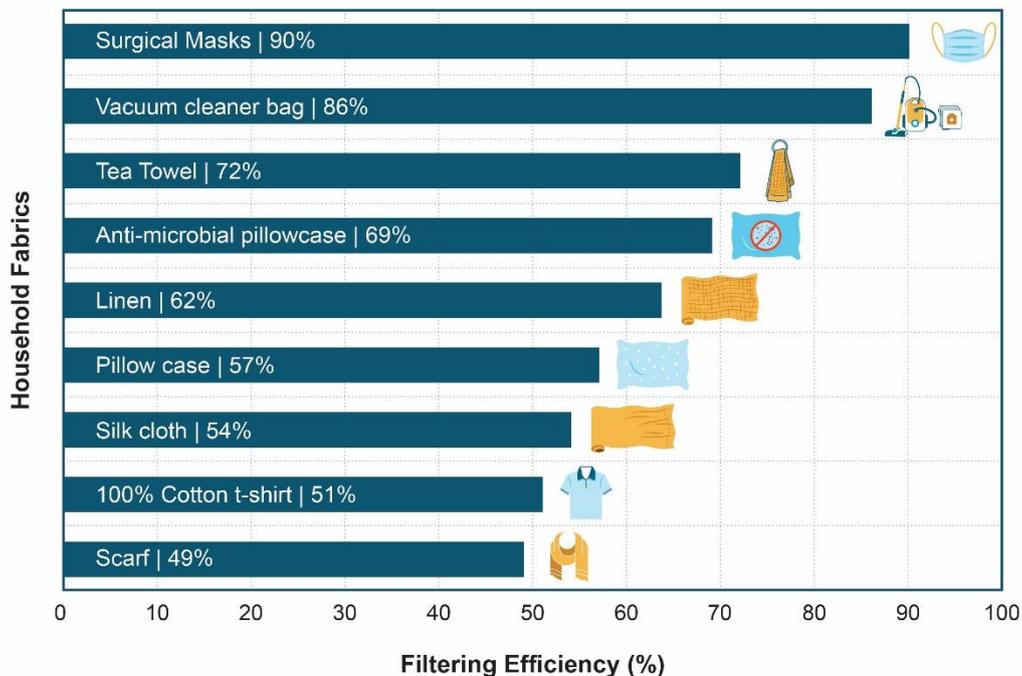


Figure 3. Filtration efficiency of various household fabrics (based on research from Davies et.al ²³)

In another study by Rengasamy et al. ²⁵, they studied the filtration performance of cloth mask and common fabric materials against poly-disperse (0.075µm median diameter) and mono-disperse (0.02-0.2 µm) NaCl aerosol and found that cloth mask provides only marginal respiratory protection. The results of poly-disperse aerosol (closer in size to coronavirus) at 5.5 cm s⁻¹ and 16.5 cm s⁻¹ suggest that the cloth masks and textile material (single layer) had a filtering efficiency in the range of 10-60% when compared to N95 respirator tested for over 95% efficiency. Sweat shirt was tested to be more efficient (18-60%; Hanes brand of 70% cotton and 30% polyester material performed best) as compared to towel (34-40%, 100% cotton slightly better than 80% polyester/20 nylon), Scarves (11-27%, 100% polyester better than 100% cotton), commercial cloth mask (10-26%, unknown fabric) and T-shirt 10-14% (cotton shirts), as illustrated in Figure 4.

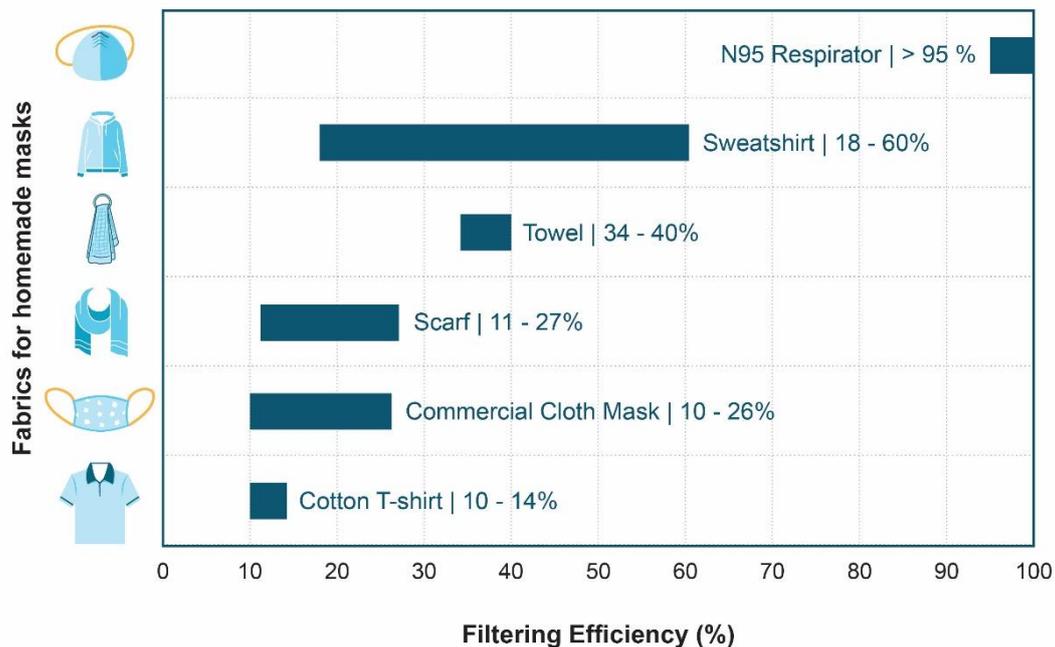


Figure 4. Filtration efficiency of various household fabrics (based on research from Rengasamy et al. ²⁵)

Van der Sande et al. ²⁶ studied short-term and long-term protection offered by respirators, surgical masks and homemade masks (made with tea cloth) and found out that all types of masks reduced aerosol exposure, independent of the duration of wear and type of activity, but with a high degree of individual variation. They found that FFP2 respirator was 50 times better than the homemade mask. MacIntyre et al. ²⁷ compared the use of cloth masks and surgical masks worn by over 1600 medical workers in Vietnam and found cloth masks to be ineffective and were not recommended for health workers. They also found that the reuse of cloth masks can increase the risk of infection.

While several studies prove that homemade masks are significantly less effective than surgical mask and respirators, researchers support the use of homemade mask, in absence of other types of masks, by a non-medical worker for influenza pandemic ^{23,26,28}. The transmission modes of the virus (droplet or aerosol) is important to understand the effectiveness of mask during the outbreak of an infectious virus. However, there is confusion amongst the scientific community if the SARS coronavirus-2 is airborne or droplet ²⁹. Human eyes are also discussed

widely as a possible route for transmission ³⁰⁻³² and therefore, using masks alone may not prevent the infection. Hence, face shields and goggles are often recommended for medical workers.

Public use of masks

While researchers agree and recommend public or community use of a mask ³³⁻³⁵, the guidelines of WHO does not recommend the use of a surgical mask for healthy individuals due to shortage of mask for medical workers and lack of evidence proving its effectiveness in preventing the spread of the virus ³⁶. WHO recommends the use of a surgical mask for infected persons or persons who are taking care of an infected person. The use of surgical masks by infected people has proven to reduce the transmission of coronavirus ⁶.

While the recommendations against using surgical masks for public use are clear, it seems that WHO has a similar (but less aggressive) take on the use of non-surgical mask for public use. This is attributed to lack of evidence that wearing cloth masks by healthy persons can prevent infection with respiratory viruses, involved uncertainties, and risks associated with wearing a mask. WHO has indicated that one of the major risks is an exaggerated sense of security provided by mask, often leading people to neglect other hygiene and physical distancing practices. Moreover, improper handling of a mask can increase the risk of self-contamination by touching (for making adjustments to the mask) and re-using contaminated mask ³⁶. It has been observed that mask wearers often remove the mask to cough, sneeze or wipe their face ³⁷, which limits the effectiveness of mask in reducing transmission. Homemade or cloth masks can be extra risky as they can retain the virus-containing droplet ^{2,27} and they are known to be less effective than other types of masks.

Reasons behind the support for public use of mask

Although several risks are associated with public use of masks, especially homemade cloth masks, it has been implemented by several countries and its importance has been supported by international agencies such European Centre for Disease Prevention and Control ³⁸. While cloth masks are ineffective in preventing the infection from others, they can lower the risk of transmission. There is evidence that the virus can spread through pre-symptomatic (before symptoms onsets, on average 5-6 days after being exposed to the virus) and asymptomatic (do not show any symptoms but are infected) individuals ³⁹⁻⁴¹. A mask can retain the respiratory droplets exhaled by infected persons who might be unaware of their infection, which can reduce the spread of infection ³⁸. Therefore, the benefit of community or public use of masks is that it can increase the chances of protecting others from own infection. However, it may not decrease the vulnerability of an individual getting infected from others.

Mask as a complementary protection measure

The use of mask alone is insufficient and ineffective and should be considered as a complementary protection to the core measures recommended to reduce the transmission of COVID-19 by WHO and ECDC. These include: Physical distancing (of at least 1m), good hand hygiene (washing hands multiple times), staying home when ill, cover nose and mouth (with an elbow or a paper tissue) while sneezing and coughing, avoid touching the mouth, nose and eyes, and working from home if possible ^{36,38}. (Figure 5)

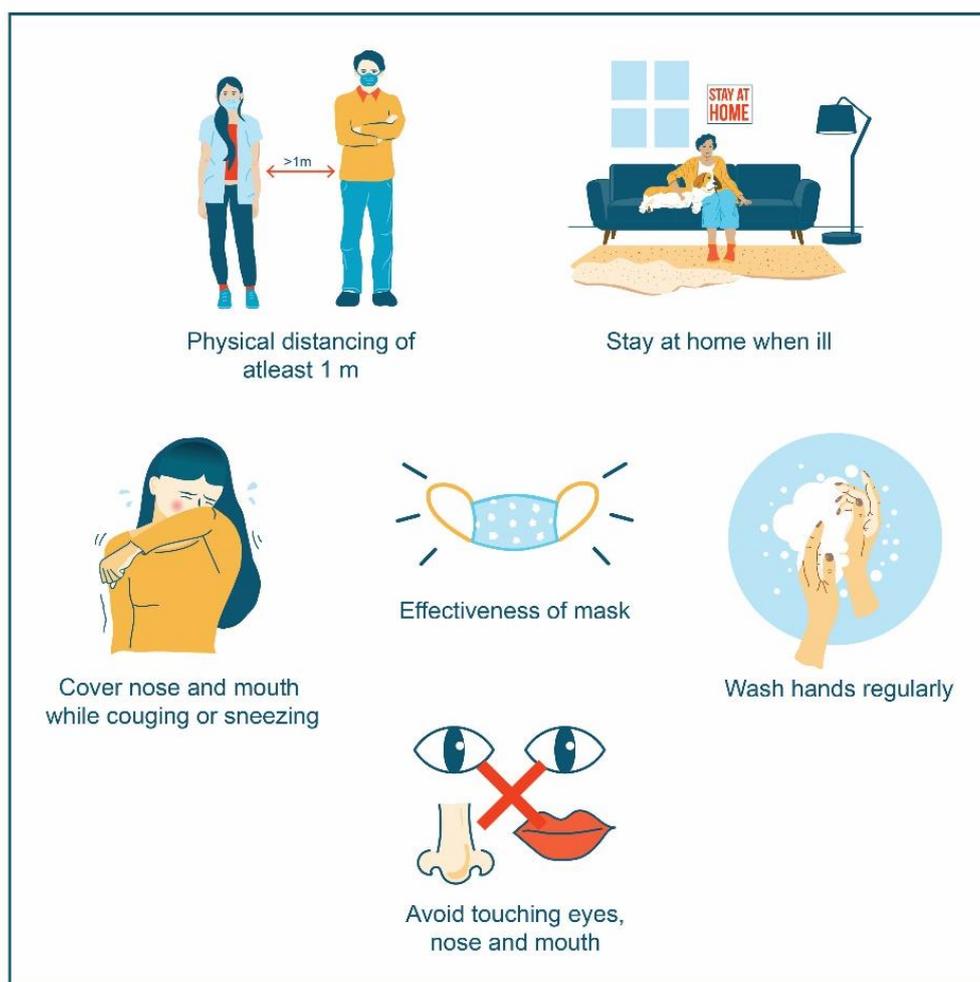


Figure 5. Core measures recommended to reduce the transmission of COVID-19

WHO and ECDC also recommend appropriate measures for using masks effectively. Some of these measures are: mask should cover nose and mouth, and tied securely to minimize gaps between face and mask; wash hands before (preventing virus getting on to mask) and after using a mask (preventing virus getting on to hands); avoid touching the mask while wearing it; while taking off a mask, do not touch the front of the mask and untie it from behind; replace mask as soon as it is damp; do not reuse single-use mask and dispose it safely and; reusable and washable mask should be washed at 60°C. ^{36,38} (Figure 6)

When used in combination with other preventive measures, masks can be effective in reducing the transmission of the virus, particularly from the infected individuals who do not show symptoms. This fact encourages public use of mask but it should be weighed against the associated risk of using masks before recommending a guideline for the public use of masks. While WHO does not support widespread public use of masks (especially surgical masks) due to lack of evidence and other concerns, several countries have now implemented the public use of non-surgical masks.



Figure 6. Some of the measures to use masks effectively

National policies on public use of non-surgical masks

Most Asian countries have made public use of masks mandatory. In some parts of India and China, not wearing a mask is even a punishable offense ^{42,43}. Masks are also recommended or compulsory in several African countries including south Africa ⁴⁴ and Morocco⁴⁵. In Europe, only a few countries have recommended the use of masks. In Austria, masks are compulsory in supermarkets, food and drug store, whereas in Slovakia, Czech republic and Bosnia and Herzegovina, it is mandatory to wear a mask outside of home ^{45,46}. In Germany where lockdown measures have been relaxed, wearing a mask on public transport, long-distance train and shops is required ⁴⁷. UK and Netherlands are following the advice given by WHO and do not recommend the use of any type of mask for healthy individuals ^{48,49}. In the US, contrary to initial advise against the use of masks, cloth masks are recommended in public settings where other social distancing measures are difficult to maintain ⁵⁰.

While some countries have agreed to the benefits of public use of masks in decreasing infection, there are no scientific evidence yet to proof the effectiveness of mask alone ⁴³. Even in countries such as Switzerland and the Netherlands, where public mask use has not been recommended, the number of cases has decreased significantly by following physical distancing and other hygiene measures.

Evidence for 'mask creates a false sense of security'

In countries with high population density such as India, the use of a homemade mask has been advised ⁵¹, and wearing masks has been made compulsory in several populated cities. Not wearing a mask can cause up to 6 months in prison ⁴². Although, most people follow the recommendation of wearing a mask in India, the practice of physical distancing has been violated in multiple instances.

While several of these violations are driven by the situation of people, such as migrant workers gathering in large numbers at bus stations to travel back to their homes ⁵²⁻⁵⁴ and difficulty to maintain physical distancing in densely populated areas; in some situations the violation of physical distancing has occurred in avoidable scenarios. For example, people were observed standing close to each other (wearing masks) outside liquor shops which were re-opened after several weeks of lockdown ⁵⁵. It is challenging to establish a strong link between wearing mask and violating physical distancing based on this evidence as other reasons may have contributed. However, in one of the cities, government officials, medical workers and media members were seen to violate the social distancing norm in a hospital during an event and when questioned about the violation of physical distancing norm, the spokesperson stated "*So, I think in the mood of excitement, people tend to make small mistakes. But I think everybody is wearing a mask, so that is probably good enough*" ⁵⁶.

These aforementioned examples reinforce the concern of exaggerated sense of protection offered by mask that has been raised by WHO. Similar instances of violating physical distancing measures have been observed in other countries such as Nigeria ⁵⁷. Excessive trust on mask has led people to violate the physical distancing measures. It is important to understand and communicate that the masks can only be effective if physical distancing and other hygiene measures are adopted.

Cultural aspect of masks

The cultural and social differences in the use of masks have led to cases of discrimination. Surgical and non-surgical masks are widely used and socially accepted in several Asian countries such as China, Thailand, South Korea and Japan, where it is considered as an important part of personal hygiene ^{2,43}. The previous experience of the 2003 SARS pandemic, increased pollution level in some parts and mask as a fashion accessory has contributed to its acceptance ⁴³. Contrary to this, in western regions such as the US and Europe, ill people are known to wear masks and therefore, a mask is representative of personal health condition. In both the regions, not following their respective cultural norm has led to stigmatisation and people have been shunned or attacked ⁴³.

The universal usage of masks can prevent racial discrimination and discrimination against people who are ill ³³. In the absence of recommendations on public use of masks, people with symptoms might also be hesitant to wear a mask in public. It is important that universal usage of masks should be recommended and not made mandatory, otherwise it could lead to problems, such as the case of an unmasked man who was dragged out of a public bus by police in the US. This incidence led to a policy change from 'mandatory use of masks' to 'recommendation on wearing masks' in the Pennsylvania public transport ⁵⁸. Wearing a mask should be promoted as an act of solidarity ³⁸ and in no case result in racial aggravations.

Summary

A mask can reduce the excretion of respiratory droplets from infected (pre-symptomatic and asymptomatic) persons who might be unaware of their infection. Therefore, public use of masks can increase the chances of protecting others from their own infection and thus, may help reducing the transmission of virus. Although homemade masks are significantly less effective, it could be used in absence of other types of masks by non-medical workers. The use of mask alone is insufficient and ineffective and should be considered as a complementary protection to the core measures recommended to reduce the transmission of COVID-19 such as physical distancing, good hand hygiene, staying home when ill and, cover nose and mouth, while sneezing and coughing.

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